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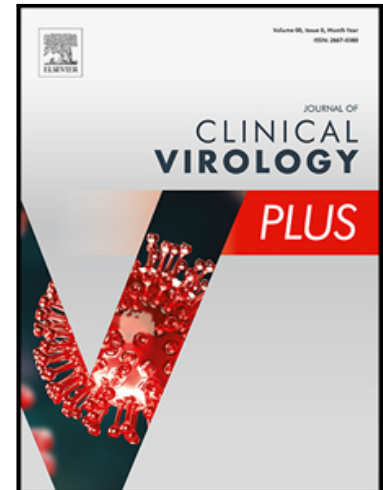
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A retrospective analysis of 902 hospitalized COVID-19 patients in Lebanon: clinical epidemiology and risk factors

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Highlights

- Description of the clinical features and case fatality rate of hospitalized COVID-19 patients admitted to a single center in Lebanon.
- Chronic immunosuppression treatment decreases the severe COVID-19 odds.
- Alveolar consolidations significantly increase the odds of COVID-19 related death.
- Lebanon's second COVID-19 wave was characterized by an increase in regular but not ICU admissions from January 2021 until May 2021.

Abstract

Background: The clinical epidemiology of hospitalized COVID-19 patients has never been described before in Lebanon. Moreover, the hospital admission and PCR positivity rates have not been assessed and compared yet. Objectives: To describe the characteristics and outcomes of hospitalized patients with coronavirus induced disease 2019 (COVID-19) in Lebanon and identify risk factors for severe disease or death. Study design: This is a retrospective mono-center cohort study in which we used patients' files to extract and analyse data on demographic and clinical characteristics, as well as mortality. Moreover, we tracked the pandemic by recording the daily total and ICU inpatient census and the PCR positivity rate for admitted and outpatients. Results: Although the total admission rate increased from September to April, the ICU census switched this trend in December to stabilize at an average of around 10 patients/day until April. The case fatality rate was 19% for the 902 hospitalized patients, of which the majority (80%) had severe COVID-19. The severity odds ratio is significantly decreased in immunosuppressed cases (OR, 0.18; CI, 0.05-0.67; $p=0.011$). Additionally, the odds of

COVID-19 related death are significantly greater if consolidations are found in the chest computed tomography (CT) scan (OR, 12; CI, 2.63-55.08; $p=0.0013$). Conclusion: Consolidations in the lungs significantly increase the COVID-19 death risk. Risk factors identification is important to improve patients' management and vaccination strategies. In addition, hospital statistics are good indicators of a pandemic's track.

Keywords: COVID-19, SARS CoV-2, Clinical characteristics, Epidemiology, Case fatality rate, Lebanon

Abbreviations: ACEI, Angiotensin-converting-enzyme inhibitors; ARB, Angiotensin receptor blockers; ARDS, Acute respiratory distress syndrome; BiPAP, Bi-level positive airway pressure; CFS, Clinical frailty scale; COPD, Chronic obstructive pulmonary disease; COVID-19, Coronavirus disease 2019; CRF, Chronic kidney failure; CT, Computed tomography; CVD, cardiovascular diseases; DVT, Deep vein thrombosis; ECMO, Extracorporeal membrane oxygenation; ER, emergency room; FM, Face mask; GGOs, Ground glass opacities; HFNC, High flow nasal cannula; ICU, Intensive care unit; MV, Mechanical ventilation; NC, Nasal cannula; NIV, Non-invasive ventilation; NRFM, Non-rebreathing face mask; OR, Odds ratio; PCR, polymerase chain reaction; PE, Pulmonary embolism; SARS-CoV-2, Severe acute respiratory syndrome coronavirus 2; SD, Standard deviation; SGH, Saint Georges Hospital; URTI, Upper respiratory tract

infection; VTE, Venous thromboembolism; WHO, World Health Organization; 95% CI, 95 percent confidence interval.

Background

In December 2019, a pneumonia outbreak linked to a new coronavirus was reported in Wuhan, China. The new virus was termed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and was responsible for coronavirus disease 2019 (COVID-19) [1]. The latter was considered a public health emergency of international concern by the World Health Organization (WHO) on 30 January 2020 [2]. The impact of infectious diseases goes well beyond mortality, with social and economic consequences being well-recognised externalities [3]. As of 22 July 2021, there have been 552,328 confirmed COVID-19 cases with 7,888 deaths in Lebanon reported to the WHO [4]. The country was already dealing with its worst economic crisis since decades [5] with a struggling healthcare system and an estimated 400 physicians to have left abroad this year [6].

Objectives

We aimed to assess a specialized COVID-19 hospital's statistics during the pandemic's second wave in Lebanon. Moreover, our objective was to describe the characteristics and outcomes of a hospitalized COVID-19 cohort. Finally, we identify risk factors for COVID-19 severity and related death.

Study Design

Study design and cohort

This is a retrospective cohort study conducted at Saint Georges Hospital (SGH), dedicated to treating COVID-19 cases since the beginning of the pandemic. The institutional review board (IRB) of Al Rassoul Hospital approved the study. We included 902 hospitalized adult COVID-19 patients with a positive polymerase chain reaction (PCR) test for SARS-CoV-2. We excluded the patients who were discharged against medical advice or transferred to other hospitals before ICU admission. Patients with an unknown outcome were excluded from the mortality analysis.

Hospital setting and participants

The SGH was transformed into a COVID-19 specialty hospital on August 27, 2020. To accommodate the rapid increase of COVID-19 cases, 45 beds and one ICU unit were added, increasing the hospital's capacity. A multidisciplinary team was established in August 2020 to manage patients using a dynamic care model (S1 Fig).

Data collection

The inpatient daily census was defined as the number of patients count in SGH or only the ICU on a given day. The last included follow-up day of the inpatient daily census

and PCR positivity analyses was May 31, 2021. For PCR data, we used 76,437 PCR tests performed at the laboratory department of SGH for both hospitalized and outpatients.

The research unit team collected the data used for the clinical epidemiology analysis. Demographic and clinical characteristics as well as COVID-19 outcomes were extracted from electronic patients' records. Patients were followed-up until death or hospital discharge after improvement. They were stratified according to severity using some specific criteria (S2 Fig).

Statistical Analyses

Analyses were performed with *GraphPad* for Windows (*GraphPad* Software, 219 La Jolla, California, USA). The primary endpoint was COVID-19 severity and the secondary was in-hospital mortality. For categorical variables, data were described as frequency and percentage [n (%)]. Mean with standard deviation (SD) was used to report continuous variables [mean (+/-SD)]. The odds ratio (OR) and between-group differences are given with their 95% confidence intervals (CI).

We used the Kolmogorov–Smirnov test to assess normality. We compared epidemiological and clinical characteristics and outcomes according to severity. Disease progression, lung radiology and outcomes were compared with or without mortality only for severe COVID-19 patients. The Mann-Whitney U test or t-test was used to

compare continuous variables. Categorical variables were analysed using the Chi-Square test (X^2 test) and Fisher's exact test. P-values were 2 sided, with statistical significance set at $p\text{-value} < 0.05$.

We performed a multivariate logistic regression to estimate factors influencing the disease severity or death. Only variables of clinical relevance with a $p\text{-value} < 0.05$ were included in the multivariable analysis. The latter was performed with *IBM SPSS Statistics* for Windows version 25 (Armonk, NY: *IBM Corp.*).

Results

Hospital statistics in the COVID-19 era

The daily hospital census of COVID-19 patients across SGH was presented for total and intensive-care unit patients (Fig 1). Both the total and ICU inpatient census increased between September 2020 and December 2020 (Fig 1A). The total inpatient census increased after January 2021 until April 2021, but the ICU inpatient census remained stable. A significant increase in the mean of the total inpatient census was observed from September 2020 ($n=33$) to March 2021 (80) ($p<0.0001$), (Figure 1B). The highest ICU inpatient census average was observed in November ($n=15$) and significantly decreased in December 2020 ($n=11$) ($p<0.0001$) (Figure 1C). Then, it stabilized at around 10 patients/day until May 2021 ($n=7$).

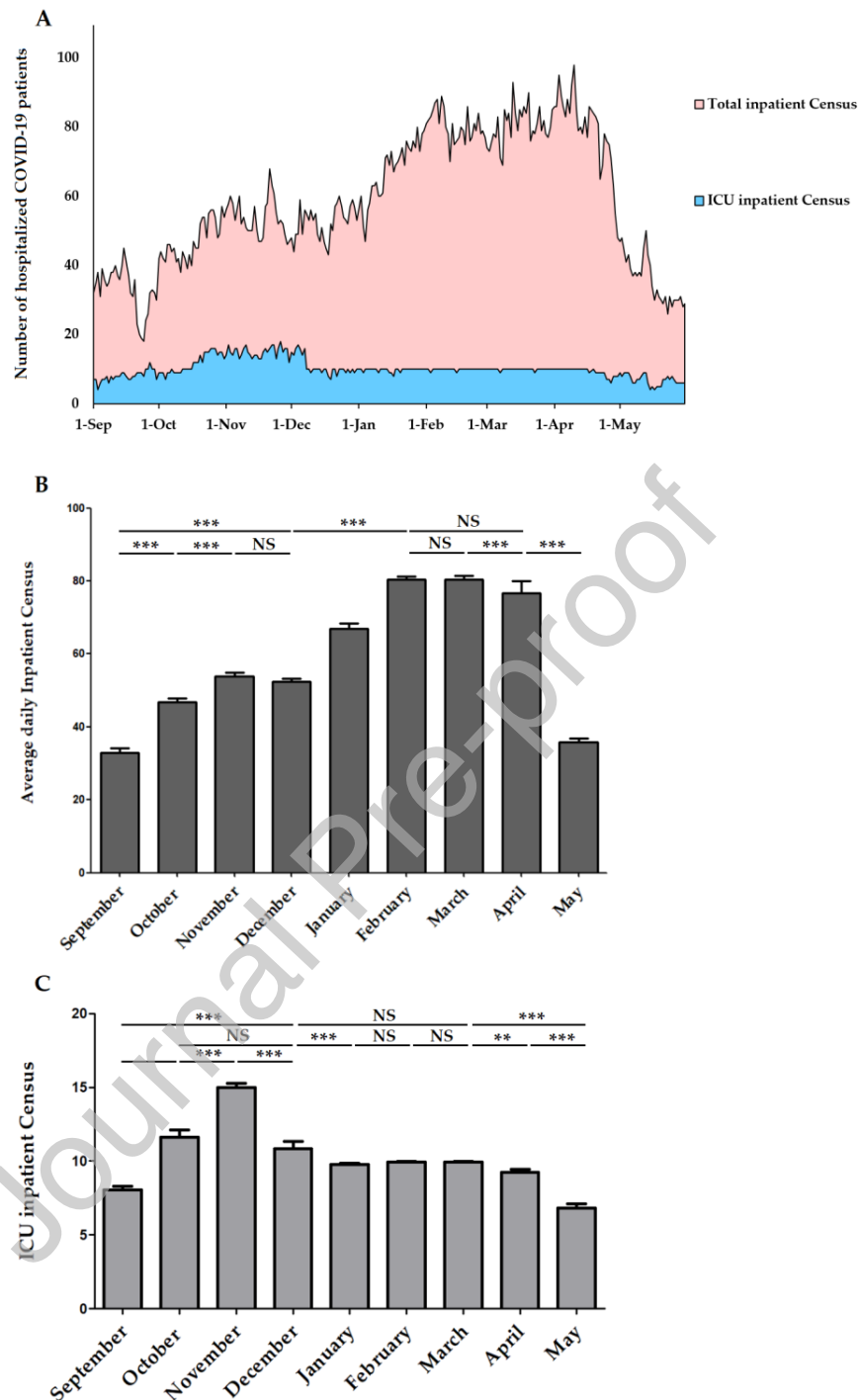


Fig 1. The SGH COVID-19 daily total hospital and ICU census (A). The inpatient hospital census averages of total [ICU and non-intensive care unit (non-ICU)] (B) and ICU (C) across SGH between September 2020 and May 2021. (600x600 dpi)

The PCR positivity rate for outpatients increased from September 2020 (22%) to January 2021 (41%) ($p<0.0001$), with a unique and significant decrease between November 2020 (34%) and December 2020 (28%) ($p=0.0002$) (S3 Fig). Exceptionally in February 2021, the PCR positivity rate had an opposite trend with that of the hospital admissions.

Epidemiology and case fatality rate

Of the 3,465 emergency room visits to SGH, a total of 934 COVID-19 patients were admitted between September 2020 and January 2021 (Fig 2).

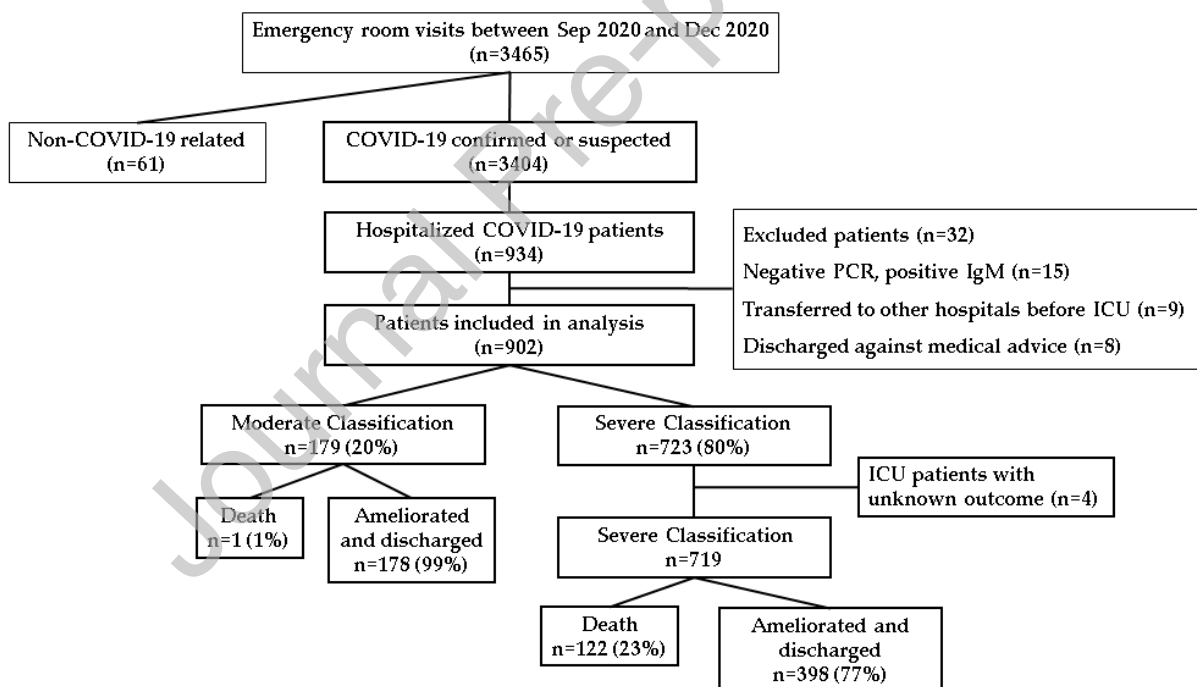


Fig 2. Flowchart of the study population. (PowerPoint file)

After the exclusion of 32 unfitting patients, we included 902 hospitalized COVID-19 patients in the retrospective analysis. Eighty percent of the admitted patients developed severe COVID-19, of which 23% died. The case fatality rate from all hospitalized COVID-19 patients at SGH was 19%.

Demographic and clinical characteristics

The mean age of our cohort was 60.5 years and most patients were male (66%) (Table 1). Around half (51%) of our patients had contact with confirmed cases a. The mean hospital stay duration for all patients was 8.8 days. The most common symptoms on admission were dyspnea (80%), fever (74%), dry cough (73.5%) and muscle/joint pain (48%). Dyspnea and dry cough were more common in severely ill patients. The incidence of anosmia was significantly higher in patients with moderate disease [moderate (13%) vs. severe (5%); $p=0.0001$].

Table 1. Epidemiological and clinical characteristics of 902 hospitalized COVID-19 patients according to disease severity. Abbreviations; ACEI, Angiotensin-converting-enzyme inhibitors; ARB, Angiotensin receptor blockers; COPD, chronic obstructive pulmonary disease; CVD, cardiovascular diseases; IQR, interquartile range; SD, standard deviation. Significant p values are highlighted in bold format.

	Hospitalized COVID-19 Patients	Patients by COVID-19 Severity		
	Total (n=902)	Moderate	Severe	p-

		(n=179)	(n=723)	value
Demographic information				
Male sex n (%)	595 (66%)	99 (55%)	496 (69%)	0.0008
Age in years, (median, IQR)	61 (49-74)	53 (43-70)	63 (51-74)	< 0.0001
Age > 60 years n (%)	461 (51%)	65 (36%)	396 (55%)	< 0.0001
Smoker n (%)	200 (22%)	37 (21%)	163 (22.5%)	0.58
Health care worker n (%)	9 (1%)	2 (1%)	7 (1%)	0.69
Contact with confirmed cases n (%)	464 (51%)	89 (50%)	375 (52%)	0.6
Travel history n (%)	15 (2%)	4 (2%)	11 (1.5%)	0.51
Mean hospital stay duration, days (±SD)	8.8 (6.4)	4.8 (2.9)	9.8 (7.6)	< 0.0001
Symptoms n (%)				
Symptoms onset to admission ≥7 days	465/894 (52%)	94/177 (53%)	371/717 (52%)	0.74
Dyspnea	726 (80%)	74 (42%)	652 (90%)	< 0.0001
Dry cough	663 (73.5%)	98 (55%)	565 (78%)	< 0.0001
Productive cough	34 (4%)	8 (4%)	26 (3.5%)	0.58
Abdominal pain	85 (9%)	28 (16%)	57 (8%)	0.0015
Diarrhea	127 (14%)	47 (26%)	80 (11%)	< 0.0001
Nausea	137 (15%)	59 (33%)	78 (11%)	< 0.0001
Fever	668 (74%)	126 (70%)	542 (75%)	0.2113
Muscle/joint pain	436 (48%)	81 (45%)	355 (49%)	0.35
Headache	180 (20%)	41 (23%)	139 (19%)	0.2701
Sore throat	77 (8.5%)	8 (4%)	69 (9.5%)	0.029
Anosmia	58 (6%)	23 (13%)	35 (5%)	< 0.0001
Comorbidities n (%)				
Hypertension	446 (49%)	72 (40%)	374 (52%)	0.0058
Diabetes	274 (30%)	43 (24%)	231 (32%)	0.038
CVD	237 (26%)	30 (17%)	207 (29%)	0.0012
Asthma	30 (3%)	6 (3%)	24 (3%)	0.98
Cancer	49 (5%)	13 (7%)	36 (5%)	0.2672
COPD /emphysema	31 (3%)	1 (1%)	30 (4%)	0.018
Chronic renal failure	35/901 (4%)	5 (3%)	30/722 (4%)	0.39
0 Comorbid conditions	321 (36%)	81 (45%)	240 (33%)	0.0026
1 Comorbid condition	228 (25%)	42 (23%)	186 (25%)	0.5329

≥ 2 Comorbid conditions	352 (39%)	56 (31%)	296 (41%)	0.0177
Treatment before presentation n (%)				
ARB or ACEI	163 (18%)	33 (18%)	130 (18%)	0.8873
Immunosuppression	52/900 (6%)	19 (11%)	33/721 (4.5%)	0.0019
Available blood group data	n= 630	n=107	n=523	
Rhesus +	566 (90%)	96/106 (91%)	470 (90%)	0.82
Rhesus -	63 (10%)	10/106 (9%)	53 (10%)	0.82
Blood type O	187 (30%)	23 (21%)	164 (31%)	0.04
Blood type A	293 (46%)	56 (52%)	237 (45%)	0.18
Blood type AB	58 (9%)	15 (14%)	43 (8%)	0.058
Blood type B	92 (15%)	13 (12%)	79 (15%)	0.43
Medical treatment n (%)				
Steroids	741 (82%)	28 (16%)	713 (99%)	< 0.0001
Baricitinib	126 (14%)	2 (1%)	124 (17%)	< 0.0001
Remdesivir	541/901 (60%)	34 (19%)	507/722 (70%)	< 0.0001
Oseltamivir	8/900 (1%)	0 (0%)	8/721 (1%)	0.36
Enoxaparin sodium	817 (90.5%)	160 (89%)	657 (91%)	0.54
Heparin	69 (8%)	10 (5.5%)	59 (8%)	0.24
Ceftriaxone	629 (70%)	81 (45%)	548 (76%)	< 0.0001
Azithromycin	416 (46%)	53 (30%)	363 (50%)	< 0.0001
Plasma transfusion	118/900 (13%)	0 (0%)	118/721 (16%)	< 0.0001
Outcome n (%)				
Patients with known outcome	898	179	719	
Discharged	724 (81%)	178 (99%)	546 (76%)	< 0.0001
Death in hospital	174 (19 %)	1 (1%)	173 (24%)	< 0.0001

Comorbidities were present in more than half of the patients (64%) and having two or more comorbidities was more common in severe disease [moderate (31%) vs. severe (41%); p=0.017]

The majority of COVID-19 patients admitted to SGH were rhesus positive (90%). Among the ABO blood groups, group A was the most abundant in our cohort (46%), while group AB was the least (9%). The blood group O was more abundant among severe patients [moderate (21%) vs. severe (31%), $P=0.04$].

Pharmacological treatment and oxygen therapy

Steroids were prescribed to the majority of our cohort (82%) and almost all of the severe cases (99%) received steroids (Table 1). Enoxaparin sodium was the main choice of anticoagulants for both moderate and severe patients. Only severe patients received O₂ therapy with a mean duration of 8.9 days (Table 2). The non-rebreathing face mask (NRFM) and bi-level positive airway pressure (BiPAP) utilization was more common among non-survivors. A small proportion of patients continued O₂ treatment at home (12.5%).

Table 2. Management and complications of 719 patients with severe COVID-19 by survival outcome. Abbreviations; ARDS; Acute respiratory distress syndrome; BiPAP, Bi-level positive airway pressure; ICU, Intensive care unit; n, Frequency; O₂, Oxygen; SD, standard deviation. Significant p values are highlighted in bold format.

	Hospitalized Severe COVID-19 Patients Total (n=719)	COVID-19 patients by outcome		p-value
		Survivors (n=546)	Non-Survivors (n=173)	

Lung radiology				
Patchy ground glass opacities	241 (33.5%)	221 (40%)	20 (11.5%)	< 0.0001
Diffuse ground glass opacities	382 (53%)	248 (45%)	134 (77%)	< 0.0001
Consolidations	83 (11.5%)	43 (8%)	40 (23%)	< 0.0001
Bilateral involvement	691/716 (96.5%)	520/545 (95%)	171 (99%)	0.038
Disease progression				
ICU admission n (%)	196 (27%)	45 (8%)	151 (87%)	< 0.0001
Mean duration of ICU stay, days (±SD)	9.5 (7.5)	9.6 (6.4)	9.5 (7.8)	0.299
ICU stay > 7 days n/n (%)	110 (1.5%)	25 (4.5%)	85 (49%)	< 0.0001
Oxygen therapy n (%)				
Nasal cannula	305 (42%)	297 (54%)	8 (5%)	< 0.0001
Face mask	127 (18%)	113 (21%)	14 (8%)	0.0002
Non-rebreathing face mask	258 (36%)	130 (24%)	128 (74%)	< 0.0001
High flow nasal cannula	48 (7%)	21 (4%)	27 (16%)	< 0.0001
O2 flow ≥ 6 L/min in NC, FM and HFNC	375/680 (55%)	240/535 (44%)	135/145 (93%)	< 0.0001
BiPAP	101 (14%)	24 (4%)	77 (44.5%)	< 0.0001
O2 therapy duration, days (±SD)*	8.9 (6.6)	7.3 (4.8)	13.8 (8.8)	< 0.0001
Non-invasive ventilation	13 (2%)	2 (1%)	11 (6%)	< 0.0001
Mechanical ventilation	151 (21%)	3 (1%)	148 (85.5%)	< 0.0001
Extracorporeal membrane oxygenation	1 (<1%)	0 (0%)	1 (<1%)	< 0.0001
Home on O2	90 (12.5%)	90 (16%)	0 (0%)	< 0.0001
COVID-19 Complications n (%)				
Pneumonia	719 (100%)	546 (100%)	173 (100%)	
ARDS	149 (21%)	10 (2%)	139 (80%)	< 0.0001
Pneumothorax	31 (4%)	12 (2%)	19 (11%)	< 0.0001
Acute coronary syndrome	59 (8%)	22 (4%)	37 (21%)	< 0.0001

Myocarditis	3 (1%)	0 (0%)	3 (2%)	0.013
Cardiac arrest	81 (11%)	0 (0%)	81 (47%)	< 0.0001
Cardiac arrhythmia	67 (9%)	8 (1%)	59 (34%)	< 0.0001
Deep Vein thrombosis	4 (1%)	1 (1%)	3 (2%)	0.045
Pulmonary Embolism	5 (1%)	0 (0%)	5 (3%)	0.0008
Acute kidney disease	282/715 (39%)	138/543 (25%)	144/172 (84%)	< 0.0001
Hemodialysis	30 (4%)	0 (0%)	30 (17%)	< 0.0001
Liver dysfunction	374/670 (56%)	269/507 (53%)	105/163 (61%)	0.0111
Septic Shock	93 (13%)	5 (1%)	88 (51%)	< 0.0001
Stroke	5 (1%)	1 (1%)	4 (2%)	0.013
Nosocomial infection	66 (9%)	21 (4%)	45 (26%)	< 0.0001

Management and complications

Among severe COVID-19 patients, 27% were admitted to the ICU with a mean duration stay of 9.5 days (Table 2). Non-survivors had more prolonged ICU stays compared to survivors. The chest computed tomography (CT) results showed that patchy ground glass opacities (GGOs) were more common among survivors, while a higher proportion of non-survivors presented with diffuse GGOs.

Both survivors and non-survivors in our severe cohort suffered from a multitude of complications. The most prevalent one was pneumonia in all patients and liver dysfunction in more than half of them (56%). The following predominant complication was acute kidney injury (39%) with the need for renal replacement therapy in 30 patients (4%). Acute respiratory distress syndrome (ARDS) was significantly prevalent

in non-survivors (80%) compared to survivors (2%) ($p < 0.0001$). Septic shock occurred in 93 patients (13%) and 66 patients (9%) had nosocomial infections. Venous thromboembolism was diagnosed in nine patients (1%).

Multivariate analysis

We performed a multivariate analysis of the data presented in tables 1 and 2 to identify predictive factors of COVID-19 severity and COVID-19-related death respectively (Table 3). Only predictors with a p-value of < 0.05 were presented.

Table 3: Predictors of COVID-19 severity and mortality. Abbreviations; CVD, Cardiovascular diseases; GGO, Ground glass opacities; 95% CI, 95 percent confidence interval.

	Univariate analysis			Multivariate logistic regression		
	Odds ratio	95% CI	P value	Odds ratio	95% CI	p-value
Endpoint: COVID-19 Severity						
Male sex	1.76	1.26 to 2.46	0.0008			
Age > 60 years	2.12	1.51 to 2.97	< 0.0001			
Blood type O	1.66	1.01 to 2.74	0.04			
Immunosuppression before COVID-19	0.4	0.22 to 0.72	0.0019	0.183	0.05 to 0.67	0.011
≥ 2 Comorbid conditions	1.52	1.07 to 2.15	0.017			
0 Comorbid conditions	0.6	0.43 to 0.83	0.0026			
CVD	1.99	1.30 to 3.04	0.0012			
Diabetes	1.48	1.01 to	0.038			

		2.16				
Endpoint: COVID-19 related death						
Age >60 years	3.4	2.31 to 5.01	< 0.0001	1.05	1.03 to 1.07	< 0.0001
≥ 2 Comorbid conditions	3.27	2.29 to 4.66	< 0.0001			
Bilateral GGOs	3.34	0.87 to 12.76	0.038			
Consolidations	2.3	1.76 to 3.01	< 0.0001	12	2.63 to 55.08	0.0013
Ferritin ≥ 4000 ng/mL	9.29	4.42 to 19.52	< 0.0001	1	1 to 1	< 0.0001
Procalcitonin ≥ 1.5 ng/mL	9.45	5.32 to 16.81	< 0.0001			
D-Dimer ≥ 5000 ng/mL	7.55	4.10 to 13.90	< 0.0001	1	1 to 1	< 0.0001

The severe COVID-19 odds ratio decreased significantly in immunosuppressed cases (OR, 0.18; CI, 0.05-0.67; p=0.011). Additionally, the odds of COVID-19-related death were significantly greater if consolidations were found in the chest CT scan (OR, 12; CI, 2.63-55.08; p=0.0013). Male sex, older age, blood type O, cardiovascular diseases (CVD), diabetes and having at least two comorbidities were significantly associated with severe COVID-19 in the univariate analysis only.

Discussion

September 2020 marked the beginning of the second SARS-CoV-2 infection wave in Lebanon. We described the hospital admission statistics at the SGH from September 2020 to May 2021. We detected a rapid increase in regular but not ICU admissions starting from January 2020 until April 2021. The B.1.1.7 SARS-CoV-2 variant was first detected in Lebanon around the end of December 2020 but may have propagated

earlier. The national COVID-19 vaccination campaign started distributing jabs from the end of February 2021 with limited doses quantity a slow vaccination rate. Vaccination is not sufficient to explain the ICU admission stabilization for around four months but can explain the hospital and ICU census decrease in May 2021. The seasonality of the infection or the propagation of other strains in Lebanon may also play a role in this decrease.

It is worth mentioning that the Lebanese government ordered a second lockdown on November 14, 2020 that may explain the decrease in total and ICU admissions and the PCR positivity rate in December compared to November. Hospital admission statistics possibly reflect community transmission since the PCR positivity rate for outpatients had a similar trend to that of the total inpatient census. During its pandemic's second wave, Lebanon was amidst the worst economic crisis since decades. Access to diagnosis and treatment was partially hindered, and shortages of dollars spawned a black market for oxygen tanks threatening its supply to hospitals. These exceptional factors make the COVID-19 pandemic management even more challenging.

Regarding the COVID-19 patients' characteristics, we assessed a hospitalized cohort from September 2020 to January 2021. Similar to previous studies, male patients were more common in our cohort [7], [8]. The median age was 61 years, lower than that of cohorts from Europe [7], [9] and the United states of America (USA) [8], [10] but higher than that of Ethiopia [11] and Kuwait [12]. A higher proportion of our cohort (51%)

were above 60 years old compared to Turkey (23%) [13]. Only 9 patients (1%) were healthcare workers, a percentage lower than that from other countries [14], [15]. Dyspnea and dry cough were the most common symptoms reported among those who developed severe COVID-19. Similar to findings from France [9], gastrointestinal symptoms were associated with non-severe COVID-19 in our cohort, including nausea and diarrhea. It was also shown previously that a greater proportion of patients who were not admitted to the ICU had diarrhea or nausea compared to those admitted to the ICU [12]. Anosmia was more common in patients with moderate COVID-19 compared with patients with severe COVID-19, a result similar to studies from Africa [11], [16]. In line with a meta-analysis of comorbidities in COVID-19 patients [17], the most prevalent comorbidity in our cohort was hypertension, followed by diabetes and cardiovascular disease. Patients without any comorbidity were more common in the moderate disease group [moderate (45%) vs. severe (33%); $p=0.0026$]. A significant proportion of patients with two or more pre-existing comorbidities developed severe COVID-19 [moderate (31%) vs. severe (41%); $p=0.0177$]. Many studies reported a similar result [9], [11] and a study from china specified hypertension, diabetes and chronic kidney disease as risk factors for severe COVID-19 [18]. The univariate analysis of OR demonstrated the increased COVID-19 severity odds for patients with the blood group O. The latter's pooled weighted OR determined by multivariate analysis from a global meta-analysis was 17.48 for severe COVID-19 [19].

Previous studies pertaining to the COVID-19 risk factors didn't include the chest CT findings in their analysis. We observed a difference in the GGO type —whether patchy or diffuse— between survivors and non-survivors. Moreover, non-survivors were more likely to develop bilateral rather than unilateral pneumonia. Only alveolar consolidations were determined to significantly increase the death odds. The chest CT profile is important to predict the COVID-19 prognosis, and those with consolidations should be considered as high risk patients.

Consistent with other studies [9], patients with chronic immunosuppression prior to infection had significantly decreased odds of developing severe COVID-19. Once admitted to the ICU, however, their management becomes very complicated. A study showed that the death odds from COVID-19 are increased for these patients [19]. However, mortality may depend on the type and duration of immunosuppression. In a large cohort of cancer patients with COVID-19, Sharafeldine et al. demonstrated that the risk of all-cause mortality was increased by hematologic malignancy. However, recent immunotherapies or targeted therapies did not increase the overall mortality risk [20]. B-cell depleting anti-CD20 antibodies are used in the treatment of hematological malignancies. They were recently shown to delay viral clearance and impair the SARS-CoV-2 antibody production, while exacerbating the inflammatory response [21]. Transplantation recipients are usually implicated in potent immunosuppression regimes to prevent acute rejection. Compared to the general population, the COVID-19

mortality outcome in kidney or liver transplant recipients is similar [22, 23]. Studies showed higher mortality ranges in lung and heart transplant recipients, possibly due to the use of higher immunosuppression doses required for this type of transplantation [24, 25]. The Adaptive COVID-19 Treatment Trial 2 (ACTT-2) [26] and the Randomized Evaluation of COVID-19 Therapy (RECOVERY) [27] trials assessed immunosuppression treatment in hospitalized COVID-19 patients without targeting immunosuppressed patients. Conducting treatment clinical trials including such group of patients is of high interest.

In the univariate analysis, age >60 significantly increased the death odds ratio. The latter was very close to one in the multivariate analysis, indicating that older age was not associated with increased mortality. Elderly patients are considered a frail population and frequently have multiple comorbid conditions. The level of fitness, rather than the age itself, may be the key player in a worse COVID-19 prognosis. Bavaro et al. used the Clinical Frailty Scale (CFS) as a useful marker of mortality in the elderly, independently of comorbidities [28]. Their study revealed a correlation between extrapulmonary manifestations and “frailty”. Moreover, the clinical picture of SARS-CoV-2 infection in the elderly is significantly different from the “usual” hypoxemic pneumonia in young or middle-aged patients. Higher CFS is associated with an elevated mortality risk in COVID-19 patients. [28].

We determined the case fatality rate to be 19% for hospitalized COVID-19 patients in Lebanon, similar to that of USA hospitals [10]. The high case fatality rate from MV (85.5%) can be reduced by prompting physicians to take the decision for earlier intubation. Taking into account recommendations from Rieg et al., all of our patients had a complete follow-up [7]. Regardless the hospital stay duration, we recorded whether they died or were discharged from the hospital after recovery. This analytical approach is superior to studies in which mortality was reported at a time when patients were still hospitalized, where the true fatality numbers may have been masked. Similar to Reig et al., our dynamic care model also limited the full ICU capacity impact on fatality rate determination.

This is the first study of its kind to be conducted in Lebanon. The relatively large sample size of hospitalized COVID-19 patients contributes to one of its strength points. Lebanon has a small area and population, so our results can be generalized to the whole country. In addition, the enrollment of all hospitalized cases irrespective of disease severity allowed for the identification of risk factors associated with both severity and mortality. As such, it was also possible to determine the proportion of severe cases in our study.

This study has some limitations, the main one being its retrospective observational nature. Moreover, risk factor analysis was limited by missing data points for key inflammatory markers shown to be associated with severe disease [29]. The treatment

strategy slightly varied and evolved over time according to the gained experience and international guidelines. Finally, we included patients with a wide COVID-19 severity spectrum. Similar to other countries [30], future studies should focus on addressing risk factors in critically ill COVID-19 patients.

Conclusions

The study's accurate reporting of hospital statistics allowed tracking the COVID-19 pandemic in Lebanon. We reported a significant increase in admissions to regular but not ICU wards at SGH, which continued until May 2021. To the best of our knowledge, this is the first study to provide a comprehensive description of COVID-19 patients admitted to a single center in Lebanon. Chronic immunosuppression treatment decreases the severe COVID-19 odds while alveolar consolidations significantly increase the death odds. Identifying risk factors is important to improve the stratification and management of at-risk patients and to implement proper vaccination strategies such as the prioritization of high risk individuals.

S1 Fig. Patient flow in the dynamic care model orchestrated by the COVID-19 multidisciplinary team at SGH. The patient arrives to the emergency room (ER) where attending physicians fully assess the case and classify it (A) According to COVID-19 severity, a patient is admitted into the relevant ward (B) and treated by a team of physicians (C). The team's members discussed in daily meetings critical or challenging cases to reach a joint decision on treatment and management (D). All hospitalized

patients had access to psychotherapy throughout their treatment journey (E). After discharge, respiratory therapy was provided to requiring cases (F). (300x300 dpi)

S2 Fig. Criteria used to stratify patients according to COVID-19 severity into moderate or severe disease. First, patients were divided into: mild, moderate, severe or critical according to WHO guidelines. Then critically and severely ill patients were pooled and categorized into severe disease. Similarly, the moderate group in our study included the sum of patients classified as mildly or moderately ill according to WHO. (300x300 dpi)

S3 Fig. SARS-CoV-2 PCR positivity rate for each month from Sep 2020 to May 2021. (300x300 dpi)

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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